The Remarkable Design of the Solar System’s Turbulent Youth, Part 1

May 30, 2011

By Dr. Hugh Ross



Among all species, humans are unique in that we, as individuals, take an exceptionally long time to develop physically and mentally.

Human males do not reach full physical maturity until the age of twenty-four. Educational training can take even longer; in my case it took until age thirty to complete all my education and post-doctorate research. We are called to fulfill highly complex, meaningful, and purposeful roles—this is the main reason we take so much longer to develop than other species.

Today, astronomers and geophysicists are discovering that what is true of human beings is also proving true of the solar system’s planets, moons, asteroids, and comets. More and more research shows that it’s one thing for the solar system to develop to support unicellular life; it’s quite another matter to reach the ability to host advanced life. Supporting human civilization presents even more daunting requirements.

In more than 40 different research papers published from late 2003 to early 2011, over a hundred astronomers and physicists have pieced together all major events that took place between about 30 million to a billion years after the solar system’s birth and that were essential for advanced life. In the next several *Today’s New Reasons to Believe*articles, I will describe what these scientists have uncovered and how these new discoveries explain, in part, Earth’s unique capacity to sustain human civilization.

In the final article I will go past what the researchers have published and analyze how their discoveries, in the context of additional work on the statistics of the properties of[extrasolar planets](http://en.wikipedia.org/wiki/Extrasolar_planet), produce a litany of new evidences establishing the supernatural design of the solar system’s planets, asteroids, and comets for humanity’s specific benefit. In the same article I will also briefly describe how these researchers’ work produces several new refutations of young-earth creationism. In this, the first article, I will describe some of the finely tuned features of the solar system’s birth and infancy that set the stage for the even more astounding design of its youth.

**Solar System’s Birth**

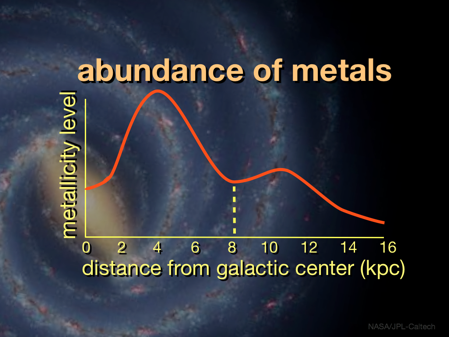
To understand the fine-tuned nature of the solar system’s youth, it is important to place it in the context of the solar system’s birth and infancy. That both the solar system and Earth experienced a remarkable birth and infancy is now well established and understood. Compared to other known planetary systems, our solar system is exceptionally [volatile-poor and refractory-rich](http://adsabs.harvard.edu/abs/2009Icar..201..821G).1 That is, it possesses little in the way of gases and liquids but a superabundance of light and heavy metals. [Goldilocks planets](http://www.absoluteastronomy.com/topics/Goldilocks_planet)are like Earth in that they possess both the carbon and liquid water that life requires. However, Earth possesses about 1,200 times less carbon-based gases in its atmosphere and about 500 times less liquid water compared to other “goldilocks” planets of similar size and approximating Earth’s surface temperature.

Astronomers now understand that the solar system’s exceptional status results from its birth in a huge cluster of at least 3,000 stars located well inside the Milky Way Galaxy’s corotation distance (see figure 1). The corotation distance is the distance from the center of a spiral galaxy, where a star would revolve around the galaxy’s center at the same rate that the galaxy’s spiral structure rotates. To put it another way, at the corotation distance a star has zero relative velocity with respect to the spiral arm pattern.

For the Milky Way Galaxy (MWG) the corotation distance is about 26,000 light-years out from the galactic center. Presently, the solar system resides just inside the MWG’s corotation distance.

*A little less than half way out from the center of the optically visible portion of our galaxy, stars revolve around the galaxy’s center at the same rate that the spiral arm pattern rotates. Stars closer to the center will revolve faster and stars more distance will revolve slower. The farther a star is from the corotation distance, the more frequently it will cross one of the galaxy’s spiral arms.*  
*Background image courtesy of NASA/JPL-Caltech/R. Hurt (SSC)*

At the corotation distance [mean motion resonances](http://www.top40-charts.info/?title=Mean-motion_resonance) disrupt star formation. This disruption limits both the stellar density and the abundance of metals, especially heavier metals. Given Earth’s extremely high abundance of such metals as phosphorus, fluorine, aluminum, titanium, uranium, and thorium, our planet and its solar system companions could not have formed anywhere near the corotation distance. They must have formed closer to the galactic center where the galactic[metallicity](http://en.wikipedia.org/wiki/Metallicity) is near peak values (see figure 2).2

  
***Figure 2: Metal Abundance Relative to Distance from the Galactic Center***  
*Powerful “waves” waft metal-rich gas outward from the galactic center resulting in aggressive star formation. The larger of these stars expel huge quantities of even more metal-rich gas into the galactic medium. Beyond 4 kiloparsecs (13,000 light-years) from the galactic center the star formation rate declines steadily (and with it the abundance of metals), reaching a minimum at the corotation distance (dotted line). Beyond 11 kiloparses (36,000 light-years) the star formation rate and metal abundance declines steadily again.*  
*The drawn curve is based on data taken from Mishurov, Lépine, and Acharova,*Astrophysical Journal Letters*571 (June 1, 2002): L113–L115.*  
*Background image courtesy of NASA/JPL-Caltech/R. Hurt (SSC)*

Only when closer to the galactic center would a birthing cluster of 3,000 or more stars be possible. Likewise, the [supernova](http://en.wikipedia.org/wiki/Supernova) production rate would be high enough to enrich the solar system with its full panoply of heavy elements only when closer to the galactic center.

Within its birthing cluster, the Sun and its emerging system of planets formed adjacent to several supergiant stars that exploded as supernovae. The explosions were not close enough to destroy or seriously disrupt the planets, but they were close enough both in distance and timing to supplement the newly forming planets with a profusion of heavy elements and to bathe the entire solar system in aluminum-26, a radioactive isotope with a half-life of 717,000 years.

Different supernova eruptions produce different suites of heavy elements; so, it was crucial for Earth’s advanced life that the Sun’s disk of protoplanetary material be exposed to the different eruptions almost simultaneously. Exposure to at least four different kinds of eruptions (including a very rare [faint supernova with mixing fallback](http://iopscience.iop.org/0004-637X/688/2/1382)) is necessary to explain Earth’s past and present mix of abundances of the 94 naturally occurring elements.3

Additionally, the Sun’s protoplanetary disk must be exposed to certain [asymptotic giant branch stars](http://en.wikipedia.org/wiki/Asymptotic_giant_branch) and [white dwarf](http://en.wikipedia.org/wiki/White_dwarf) binary stars at just the right distance and timing. It takes the precise exposure to all of these different kinds of stars at the just-right times in their evolutionary history to supply the Sun’s emerging planets with adequate amounts of all 94 natural elements (plutonium and neptunium though present on early Earth have since completely decayed away) in the [periodic table](http://en.wikipedia.org/wiki/Periodic_table).

Some of the lighter elements, especially hydrogen, carbon, and nitrogen, would be far too abundant for the existence of advanced life if it not for the primordial solar system being bathed in huge quantities of [aluminum-26](http://en.wikipedia.org/wiki/Aluminum-26). In fact, while aluminum comprises less than 0.01 percent of the universe’s ordinary matter, it makes up 8.1 percent of Earth’s crust (900 times more abundant).

A just-right combination of nearby supernova eruptions showered the solar system’s developing planets with aluminum-26. The intense heat released from the isotope’s radioactive decay drove off most of the volatiles (gases and liquids), leaving the solar system planets volatile-poor and refractory-rich. The aluminum-26 drove off a greater percentage of volatiles from planets smaller and closer to the Sun.

In 2009, [two British astronomers pointed out](http://adsabs.harvard.edu/abs/2009Icar..201..821G) that early exposure to an unusually extreme amount of aluminum-26 explains why the solar system’s planets are so very volatile-poor compared to the [hundreds of exoplanets](http://exoplanet.eu/catalog.php) now discovered.4 Plus, the solar system’s early exposure to aluminum-26 also helps explain why Earth’s crust is so abundant in aluminum-27 (aluminum’s non-radioactive isotope), because large quantities of aluminum-26 mean large amounts of aluminum-27.

**Solar System’s Infancy**

For advanced life to ever be possible, the Sun and its young planets, asteroids, and comets could not remain long in their birthing star cluster. Too much time in the birthing cluster would result in the planets suffering gravitational disturbances and radiation exposure from nearby massive stars. However, a just-right encounter with a highly specified set of giant stars at the just-right time strongly ejected the entire solar system from its birthing cluster intact.

Not just any kind of ejection would do, however. The solar system had to be ejected outward in the opposite direction from the galactic center, along a trajectory that avoided any points of danger. That is, the trajectory path steered clear of close encounters with giant stars, x-ray and gamma-ray sources, and giant molecular clouds. The ejection brought the solar system’s radial velocity (outward movement within the MWG) to a halt just before the solar system reached the corotation distance.

As noted earlier, residing *right at* the corotation distance would have resulted in destructive mean motion resonances. But *just inside* the corotation distance the solar system experiences few spiral arm encounters and few gravitational encounters with other stars.

For the possibility of advanced life on Earth, the solar system had to be born in one of the most dangerous locations in the MWG and then ejected relatively quickly into the MWG’s safest location. The solar system’s birth was not ordinary. Everything about the solar system’s genesis appears exquisitely fine-tuned to make possible the future existence of advanced life and human beings in particular.

In part 2 of this series I will describe events that took place during Earth’s toddlerhood (the first ten and a hundred million years of our planet’s history).

In [part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-1) of this series on the solar system’s youth I described the solar system’s exquisitely fine-tuned birthing experience. Here, in part 2, I will describe amazing events that took place in the solar system’s toddlerhood. As with the solar system’s birthing experience, these events had to be perfectly fine-tuned in order for advanced life on Earth to have a chance.

**Just-Right Gas Giant Planets**

The solar system requires a very particular suite of gas giants for a planet like Earth to be possible. For example, about a decade ago, a [team of five American and Canadian astronomers discovered](http://adsabs.harvard.edu/abs/2003AJ....125.2692L) that the nature of a planetary system’s small rocky planets is usually the result of how efficiently the local gas giants dynamically excite the rocky planet embryos.1 Increased excitement in the embryos results in fewer rocky planets that are more massive and the closer to the central star. For advanced life to be possible this excitement level must be just right.

A suite of gas giants is also essential to protect life on a habitable rocky planet from taking too many destructive hits from asteroids and comets. Such a group of planets acts like a [gravitational shield for the habitable planet](http://www.reasons.org/catalog/more-theory); their gravitational potentials either deflect projectiles away form the habitable planet or result in they themselves absorbing comets and asteroids.2

However, if the gas giant planets are either too small or too distant, the shielding will be inadequate. On the other hand, if they are too large or too close, their gravitational potentials will disrupt the habitable planet’s orbit.

Our solar system’s suite of gas giant planets (Jupiter, Saturn, Uranus, and Neptune) had to exhibit the just-right masses, just-right distances from the Sun, and just-right orbital configurations so Earth’s own mass, distance from the Sun, and orbital features could be just-right for supporting advanced life. At the same time, the gas giant planets must be designed to provide optimal gravitational shielding for our home planet.  
     
**Just-Right Moon-Forming Event**

As I described in part 1, extraordinary events during the solar system’s birth led to the Sun’s planets becoming extremely volatile-poor and refractory-rich. But though those events rid Earth of most of  its volatiles, they still left our planet with far too much water and far too thick an atmosphere for it ever to support advanced life. Something truly outstanding must have occurred soon after Earth’s formation to scrub away nearly all its remaining volatiles so as to make it a fit candidate for sustaining plants, animals, and people. Enter the Moon-forming event.

The Moon’s anomalous nature has intrigued astronomers for centuries. Compared to the mass of its planet, the Moon is fifty times larger than any other moon in the solar system. Dynamical models in use during my graduate school days all predicted that the Moon was impossible. Our Moon was too large, too close to Earth, and Earth too close to the Sun for the Moon to ever form out of the Sun’s protoplanetary disk. All collision scenarios either resulted in the destruction of Earth, failure to form the Moon, or the formation of an Earth-Moon system with orbital features radically different from what astronomers observe. At the time, some researchers went so far as to concede that the Moon must be some kind of miracle.

Today, astronomers understand that the existence of the Moon does not violate any of the laws of physics. Nevertheless, the conditions under which the Moon formed are so remarkable as to render it an excellent example of supernatural design for humanity’s specific benefit. In order for the Moon to form, Earth needed to receive a just-right impactor at the just-right time under just-right conditions and circumstances (see figure 1). Astronomers call the impactor Theia.

In order for the impact to generate a debris disk from which a lunar-sized satellite could form, vapor gases could not dominate that debris disk.3 [Such gases generate spiral shocks](http://iopscience.iop.org/0004-637X/638/2/1180) that lead to the destruction of circumterrestrial disks (a debris disk surrounding Earth) within just a few days. Fortunately, the planets’ low volatile levels helped limit the quantity of available vapor gases. But even without significant quantities of volatiles, a gas-dominated circumterrestrial disk still could have occurred if the impact energy was high. High impact energy would have vaporized the rocky material either in Earth, the impactor, or both.

But several just-right circumstances limited the impact energy. Primordial Earth was slightly smaller than its present size at the time of the impact and the impactor itself was no more than about 20 percent of Earth’s mass. Plus, the collision impact angle was about 45 degrees and the impactor velocity was less than 12 kilometers per second. If any of these circumstances had differed too greatly, the impact energy would have been too high.

In 2000, planetary astrophysicists [William Ward and Robin Canup confirmed](http://adsabs.harvard.edu/abs/2000Natur.403..741W) that the Moon’s substantial orbital inclination relative to Earth’s equator could be explained only if the Moon formed out of an impact-generated circumterrestrial disk.4 In 2001, Canup and Erik Asphaug used a method known as [smooth particle hydrodynamics](http://en.wikipedia.org/wiki/Smoothed-particle_hydrodynamics) to produce a model for Moon formation that correctly predicted the [Moon’s low iron amounts](http://www.sciencemag.org/content/268/5214/1150.abstract)5 as well as the mass and angular momentum for both the Moon and Earth.6[This model](http://adsabs.harvard.edu/abs/2001Natur.412..708C) established that the Moon formed near the very end of Earth’s accumulation of material from the Sun’s protoplanetary disk. That is, the Moon must have formed between 30 and 50 million years after Earth’s initial formation.

In 2004, Canup produced a much more [detailed model for Moon formation](http://adsabs.harvard.edu/abs/2004Icar..168..433C).7 She achieved her best results for a collision impact angle of 45 degrees, an impactor mass between 0.11 and 0.14 Earth masses (Mars = 0.11 Earth masses), and an impactor velocity relative to Earth of less than 4 kilometers per second (typical meteorite velocities relative to Earth = 50 kilometers per second).

Canup continued her research and in 2008, developed the [most detailed and accurate model to date](http://adsabs.harvard.edu/abs/2008Icar..196..518C) for the Moon’s formation. For the first time she took into account the rotation rate and the direction of rotation for both the impactor and the toddler Earth.8 She achieved the best match for the current Earth-Moon system’s angular momentum with an impactor up to nearly twice the mass of Mars colliding into a retrograde rotating proto-Earth.

[Two Japanese astronomers](http://adsabs.harvard.edu/abs/2005Natur.433..842G) have also contributed to scientists’ understanding of the Moon-formation event. They demonstrated that a deep liquid water ocean on primordial Earth’s surface ensured that the Moon-forming impact blasted away enough of the planet’s initial atmosphere and ocean.9 Deep liquid water at the impact site lowered the shock impedance compared to bare ground. Thanks to a low shock impedance and plentiful water, the impact generated a huge amount of superheated steam, which ejected almost all Earth’s primordial water and atmosphere into interplanetary space. To guarantee that neither too much nor too little of Earth’s primordial atmosphere and ocean is removed, the primordial ocean depth had to be extremely fine-tuned.

The shock impedance also had to be fine-tuned to not only remove the just-right amounts of water and atmosphere, but also ensure that the just-right amounts of the heavier elements (especially iron, uranium, and thorium) were transferred from the collider into Earth’s core and mantle. In order for the shock impedance to be sufficiently low to make all this happen, the collider, as already confirmed by Canup’s models, had to strike Earth at a low impact angle and a very low velocity.

It is challenging, to say the least, to develop a solar system scenario that would produce such an exquisitely fine-tuned collision. Some researchers try to explain it by suggesting that the collider actually shared Earth’s orbit about the Sun. [Newtonian mechanics](http://en.wikipedia.org/wiki/Newton%27s_laws_of_motion) allows for this possibility at either the L4 or L5 [Lagrange points](http://www.physics.montana.edu/faculty/cornish/lagrange.html) (see figure 2). A smaller planet situated 60 degrees back or forward along Earth’s orbit can remain there in a stable orbital configuration, providing the Sun is at least 25 times more massive than Earth. Since the Sun is actually 333,400 times more massive, the stability condition is easily met.

*Joseph-Louis Lagrange, a French mathematician, discovered that Newtonian mechanics allows for five special points in the vicinity of two orbiting masses where a third, smaller mass can orbit at a fixed point from the larger masses. Of the five points only two, the L4 and L5, are stable over long time periods.*

The stability condition assumes, however, that only three massive bodies are involved. The presence of other planets in the solar system, particularly the presence of Jupiter and/or nearby planetesimals, means that given sufficient time the smaller planet sharing Earth’s orbit would have been wriggled away slightly from its Lagrange point. When this happened, there existed a substantial possibility that the smaller planet crept toward Earth and eventually collided with it at a low velocity and a low impact angle.

The Moon-forming impact presents all humanity with a dramatic set of evidences for supernatural, super-intelligent design for our specific benefit. Thanks to the exquisitely fine-tuned nature of this impact event, the collision:

1. Replaced Earth’s thick, suffocating atmosphere with one that possesses the perfect air pressure for efficient lung performance,10 ideal heat-trapping capability, and just-right transparency for efficient photosynthesis.
2. Gave the new atmosphere the optimal chemical composition to foster advanced life.
3. Augmented Earth’s mass and density enough to allow it to gravitationally retain a large, but not too-large, quantity of water vapor for billions of years.
4. Raised the amount of iron in Earth’s core close to the level needed to provide the planet with a strong, enduring magnetic field (the remaining iron came from a later collision event—see part 3 in this series). This magnetic field shields life from deadly cosmic rays and solar x-rays.
5. Delivered to Earth’s core and mantle quantities of iron and other critical elements in just-right ratios to produce sufficiently long-lasting, continent-building plate tectonics at just-right levels. (Fine-tuned plate tectonics also perform a crucial role in[compensating for the Sun’s increasing brightness](http://www.reasons.org/catalog/more-theory).11)
6. Increased the iron content of Earth’s crust, permitting a huge abundance of ocean-dwelling phytoplankton that in turn supports the entire oceanic food chain *and*provides the oxygen for advanced terrestrial life.12
7. Salted Earth’s interior with an abundance of long-lasting radioisotopes, the heat from which drives most tectonic activity and volcanism.13
8. Produced the Moon, which [gradually slowed Earth’s rotation rate](http://adsabs.harvard.edu/abs/2004AsBio...4..460W) so that eventually advanced life could thrive.14
9. Produced a Moon with the just-right mass and distance relative to Earth to stabilize the planet’s rotation axis tilt, protecting the planet from rapid and extreme climatic variations.15
10. Produced a Moon with the just-right diameter and distance relative to Earth so that humans would witness perfect solar eclipses during the narrow epoch in solar system history when human life is possible.16

Clearly, we humans have a lot to thank God for in the different ways He designed and timed the Moon-forming impact event. If it was not for the fine-tuning of that event and of the Moon’s present-day properties, we, and our high-technology civilization, would be impossible. On Earth’s birthday 4.5662 billion years ago and the Moon’s origin 4.53 billion years ago, God was expressing His great love for us all. In part 3 of this series I will describe additional miraculous events that occurred during the solar system’s youth—the epoch between 50 million to a billion year after the solar system’s birthday—that further prepared Earth to receive advanced life.

More and more research shows that it’s one thing for the solar system to support unicellular life; it’s quite another matter to reach the ability to host advanced life. Supporting human civilization presents even more daunting requirements. The major events that took place between about 30 million to a billion years after the solar system’s birth present a picture of exquisite fine-tuning necessary for humanity’s existence.

In [part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-1) of this series I described the solar system’s birthing experience. [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2)outlined the 50 million years of fine-tuning following the solar system’s birth, particularly (1) the configuration of the solar system’s gas giant planets and (2) the collision event that formed the Moon and helped prepare Earth to support humanity. In parts 3 and 4, I will describe other fine-tuned events that took place during the next 800 million years of the solar system’s history.

**Hostile Conditions**

During the first 700 million years of solar system history the Sun was especially unstable—making the solar system hostile to life. Not only was the [Sun’s x-ray and ultraviolet radiation](http://iopscience.iop.org/2041-8205/731/2/L29) output orders of magnitude greater than it is now, but it was also highly variable.1 (See figure 1.) Also during this epoch, the [Sun lost between 15–20 percent of its mass](http://iopscience.iop.org/0004-637X/713/2/1108).2 This mass loss translates into the Sun dimming by a factor of two because the luminosity of a star increases in proportion to the fourth power of its mass.

Additionally, huge belts of planetesimals (small bodies in the process of planetary formation), comets, and asteroids delivered frequent colliders to Earth and the other inner solar system planets. At this time, too, the solar system’s gas giant planets had not yet evolved to attain their present orbits. The closer proximity of Jupiter, Saturn, Uranus, and Neptune’s orbits disturbed Earth’s orbit significantly.

Thousands of years ago, Moses recorded in Genesis 1 that, previous to the six creation days (Genesis 1:2), Earth was “formless and void.” The Hebrew phrase *[tohu wabohu](http://www.reasons.org/catalog/origins-life" \t "_blank)* connotes a seething, uninhabitable, and empty chaos.3 It looks like scientists’ recently acquired knowledge of the early solar system’s hostility toward life yields yet one more piece of evidence for the Bible’s predictive power.

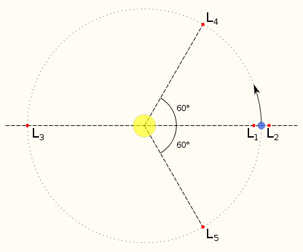
**Taming the Gas Giants**

The youthful solar system’s enormous population of planetesimals, asteroids, and comets was most predominant at the orbital distances of Jupiter, Saturn, Uranus, and Neptune. These asteroids and comets interacted gravitationally with the gas giants in a way that caused the planets (1) to gradually drift outward away from the Sun, and (2) to develop orbits free of [mean motion resonances](http://en.wikipedia.org/wiki/Orbital_resonance). Both effects benefitted Earth in that Earth’s orbit suffered less-frequent and less-dramatic gravitational disturbances from the gas giant planets.

The best formation models for the gas giants indicate that these planets formed on quasi-circular, quasi-coplanar orbits that, if unchanged, would have resulted in mean motion resonances damaging to advanced life on Earth. A [team of four planetary scientists](http://www.nature.com/nature/journal/v435/n7041/abs/nature03539.htmlhttp:/www.nature.com/nature/journal/v435/n7041/abs/nature03539.html) found a possible way to prevent this destructive scenario. Their research suggests that Jupiter and Saturn approaching, attaining, and leaving a 1:2 orbital resonance would prevent such a permanent mean motion scenario.4 In a 1:2 resonance Jupiter makes exactly two orbits of the Sun for every single orbit of Saturn.

According to the team’s research, the 1:2 orbital resonance event arose because Saturn was closer than Jupiter to the densest portion of the cloud of planetesimals, asteroids, and comets. This configuration, plus the fact that Saturn’s mass = 0.299 of Jupiter’s mass, caused Saturn to migrate outward from the Sun at a faster rate than Jupiter. Therefore, Jupiter’s orbit evolved from making less than two orbits about the Sun for every single Saturn orbit, to briefly attaining exactly two orbits for every single one of Saturn’s, and finally to making slightly more than two orbits for every single Saturn orbit.

The planetary science team proved that a carefully crafted and timed 1:2 orbital resonance event between Jupiter and Saturn produced “all the important characteristics of the giant planets’ orbits, namely their final semi-major axes [distances from the Sun], eccentricities, and mutual inclinations.”5 [In a separate research paper](http://www.nature.com/nature/journal/v435/n7041/abs/nature03540.html) the same team showed that such a 1:2 orbital resonance event also produced both the orbital distribution and the total mass of the 4,000+ [Trojan asteroids](http://en.wikipedia.org/wiki/Jupiter_trojan) that now share Jupiter’s orbit approximately.6 The solar system’s Trojan asteroids orbit the Sun near Jupiter’s two Lagrangian points of stability (see figure 2), located 60 degrees ahead and behind Jupiter in its orbit.



***Figure 2: Jupiter’s Lagrange Points***  
*Joseph-Louis Lagrange, a French mathematician, discovered that Newtonian mechanics allows for five special points in the vicinity of two orbiting masses where a third, smaller mass or several much smaller masses can orbit at a fixed point from the larger masses. Of the five points only two, the L4 and L5, are stable over long time periods. At both L4 and L5 along Jupiter’s orbit a total of 4,078 asteroids have been discovered.*

In a third research paper, the team demonstrated that the 1:2 orbital resonance event also yielded the long-sought answer to the cause of the [Late Heavy Bombardment](http://www.nature.com/nature/journal/v435/n7041/abs/nature03676.html)(LHB).7 Next week, I’ll describe the LHB and how it, like the events discussed above, prepared the solar system and Earth for the arrival of human beings.

|  |
| --- |
| [Part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-systems-turbulent-youth-part-1) | [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2) | Part 3 | [Part 4](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-4) | [Part 5](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-5) | [Part 6](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-6) |

Subjects: Astronomy and the Bible, Extrasolar Planets, Solar System Design

Want to leave a comment on this article?

Top of Form

Email Address

Questions or Comments



[Sign me up for the RTB newsletter](http://www.reasons.org/Subscribe)

Bottom of Form

Your comments are welcome.   
Please use the form to the right.

Dr. Hugh Ross

Reasons To Believe emerged from my passion to research, develop, and proclaim the most powerful new reasons to believe in Christ as Creator, Lord, and Savior and to use those new reasons to reach people for Christ. [Read more about Dr. Hugh Ross.](http://www.reasons.org/about/who-we-are/hugh-ross)



**Endnotes:**

1. Sylvaine Turck-Chièze, Laurent Piau, and Sébastien Couvidat, “The Solar Energetic Balance Revisited by Young Solar Analogs, Helioseismology, and Neutrinos,”*Astrophysical Journal Letters*731 (April 20, 2011): id L29.  
2. Turck-Chièze, Piau, and Couvidat, “Solar Energetic Balance,” id L29; Joyce Ann Guzik and Katie Mussack, [“Exploring Mass Loss, Low-Z Accretion, and Convective Overshoot in Solar Models to Mitigate the Solar Abundance Problem,”](http://iopscience.iop.org/0004-637X/713/2/1108) *Astrophysical Journal* 713 (April 20, 2010): 1108–19.  
3. Fazale Rana and Hugh Ross, *Origins of Life* (Colorado Springs: NavPress, 2004), 37–40.  
4. K. Tsiganis et al., “Origin of the Orbital Architecture of the Giant Planets of the Solar System,” *Nature* 435 (May 26, 2005): 459–61.  
5. Ibid., 459.  
6. A. Morbidelli et al., “Chaotic Capture of Jupiter’s Trojan Asteroids in the Early Solar System,” *Nature* 435 (May 26, 2005): 462–65.  
7. R. Gomes et al., “Origin of the Cataclysmic Late Heavy Bombardment Period of the Terrestrial Planets,” *Nature* 435 (May 26, 2005): 466–69.

Throughout this article series, I’ve highlighted major events that took place during our solar system’s youth and helped pave the way for the eventual appearance of humanity. In [part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-systems-turbulent-youth-part-1), I described the solar system’s birthing experience. [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2) outlined the 50 million years of fine-tuning following the solar system’s birth, particularly (1) the configuration of the gas giant planets and (2) the collision event that formed the Moon. In [part 3](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-3), I began describing other fine-tuned events that took place during the next 800 million years of the solar system’s history, specifically the Sun’s instability and the migration of Jupiter and Saturn into their present orbits.

This week, I will pick up where I left off in part 3 and discuss a turbulent time in Earth’s history known as the Late Heavy Bombardment (LHB), a relatively brief episode that occurred 700 million years after the solar system planets formed, during which hundreds of thousands of asteroids and comets bombarded Mars, Earth, the Moon, Venus, and Mercury. In 2005, a team of four planetary scientists published a total of four papers describing a possible 1:2 orbital resonance event between Jupiter and Saturn (see part 3). In their third paper, the team showed that this event also yielded the long-sought [answer to the cause of the LHB](http://www.nature.com/nature/journal/v435/n7041/abs/nature03676.html).1

**Origin of the Cataclysmic Late Heavy Bombardment**

Radiometricly dated ages of impact melt rocks collected during Apollo missions 15, 16, and 17 provided the first evidence for the LHB. These measurements produced dates that clustered between 3.8 and 4.0 billion years ago. Subsequently, astronomers measured the erosion patterns on the Moon craters. (The Moon possesses a very thin atmosphere of mostly argon gas that erodes its craters slightly over the course of a few billion years.) These erosion patterns demonstrated that over 90 percent of the Moon’s craters formed about 3.9 billion years ago.

Subsequent to that discovery, astronomers measured the erosion patterns of both Mercury’s (see figure 1) and Mars’ craters. These [measurements and others confirmed](http://adsabs.harvard.edu/abs/2006EM%26P...98...97M) that the entire inner solar system suffered a cataclysmic bombardment of asteroids and comets that spanned no more than a hundred million years between 3.95 and 3.80 billion years ago and peaked between 3.90 and 3.85 billion years ago.2

In their third paper, the planetary science research team showed that when the 1:2 orbital resonance between Jupiter and Saturn occurred it destabilized the orbits of Uranus and Neptune. This, in turn, disrupted the huge cloud of planetesimals, asteroids, and comets orbiting in the vicinity of the four gas giants, triggering a sudden delivery of hundreds of thousands of projectiles into the inner solar system. The team also established that the disruption strongly perturbed the asteroid belt between Jupiter and Mars. The combined effect perfectly explains the LHB.

[In a fourth paper](http://adsabs.harvard.edu/abs/2008Icar..196..258L), the team determined that the 1:2 orbital resonance event [explains all the observed features of the [Kuiper Belt](http://en.wikipedia.org/wiki/Kuiper_belt" \t "_blank), as well as Neptune’s orbit.3 The Kuiper Belt (see figure 2) is a region of the solar system that extends from the orbit of Neptune at 3 billion miles from the Sun out to slightly more than 5 billion miles from the Sun. In this zone astronomers have discovered, in addition to Pluto, three dwarf planets or plutoids—Eris, Haumea, and Makemake—and over a thousand asteroids and comets. What they have found so far causes them to conclude that at least 70,000 bodies bigger than 100 kilometers (62 miles) in diameter must exist in the Kuiper Belt. Astronomers estimate that the total mass of Kuiper Belt objects is about one hundred times greater than the total mass of the [Main Belt](http://en.wikipedia.org/wiki/Asteroid_belt) asteroids that reside between the orbits of Mars and Jupiter.

Specifically, the planetary scientists showed that the solar system’s primordial disk of planetesimals—initially centered roughly on Saturn’s orbit—must have been truncated at roughly 3 billion miles outward from the Sun. This truncation would explain the sudden halt in Neptune’s outward migration and the position of its present orbit. This means that the Kuiper Belt was empty initially. However, the 1:2 orbital resonance event between Jupiter and Saturn thrust what remained of the huge cloud of planetesimals, asteroids, and comets outward to between the orbits of Uranus and Neptune. That event also excited the eccentricity of Neptune’s orbit to a value as high as 0.3 (eccentricity of a circle = 0, of a parabola = 1, of an ellipse = greater than 0 but less than 1). Interaction between the cloud and Neptune with its high eccentricity orbit explains eight present-day characteristics of the outer solar system:

1. The distance of Neptune’s orbit from the Sun
2. The extremely low eccentricity of Neptune’s orbit
3. The coexistence of both a resonant and non-resonant population of Kuiper Belt objects
4. The eccentricity inclination distribution of the plutoids and [plutinos](http://en.wikipedia.org/wiki/Plutino" \t "_blank)
5. The outer edge of the Kuiper Belt at the 1:2 mean motion resonance with Neptune
6. The correlations between inclination and physical properties of classical Kuiper Belt objects
7. The existence of an extended scattered disk within the Kuiper Belt
8. The bimodal inclination distribution of classical Kuiper Belt objects

The team definitively established that the [present-day Kuiper Belt is the leftover remnant](http://adsabs.harvard.edu/abs/2006DPS....38.5403M) of the enormous cloud of planetesimals, asteroids, and comets that originally centered roughly on Saturn’s orbit.4 The fact that the Kuiper Belt, as large and as massive as it is, is only about 1 percent the size of the original cloud testifies to the catastrophic nature of the Jupiter-Saturn resonance event.

Over the course of six years, the planetary science research team has established a remarkable breadth of solar system features explained by the 1:2 orbital resonance event between Jupiter and Saturn. Other groups have added to the list of features explained by the event:

* [characteristics of Saturn’s rings and moons](http://adsabs.harvard.edu/abs/2009Icar..199..413C),5
* the [elimination of the E-Belt of asteroids](http://adsabs.harvard.edu/abs/2010LPI....41.1269B)6 (part of the primordial Main Belt that orbited close to Mars’ orbit),
* the [heavy element enrichment of the gas giants’atmospheres](http://adsabs.harvard.edu/abs/2009P%26SS...57..816M),7
* [contamination of the Main Belt by primordial trans-Neptunian objects](http://adsabs.harvard.edu/abs/2009Natur.460..364L),8
* the orbital characteristics of the [Eos family](http://en.wikipedia.org/wiki/Eos_family) of asteroids,9 and
* the elevated abundances of highly siderophile (iron-loving) elements (rhenium, osmium, iridium, ruthenium, platinum, and palladium) [in the mantles of Earth, Mars, and the Moon](http://www.sciencemag.org/content/330/6010/1527.abstract).10

But the LHB did more to Earth than just load it up with highly siderophile elements. It[altered the tilt of the planet’s rotation axis](http://www.sciencemag.org/content/330/6010/1527.abstract) by as much as 10 degrees.11 It infused Earth’s core with extra sulfur, oxygen, iron, uranium, and thorium12 and removed much of [Earth’s chlorine and other halogens](http://adsabs.harvard.edu/abs/2009AGUFM.V13H..05S).13 It also reconfigured the planet’s atmosphere, crust, mantle, outer core, and inner core.

The details of the 1:2 orbital resonance event and the LHB play a significant role in making possible the existence of advanced life on Earth. Next week, I will explain how these design details, plus a newly discovered feature, help establish that a supernatural, super-intelligent Creator was intimately involved in ensuring that the solar system and Earth, in particular, had the just-right “childhood” history to prepare them for sustaining human beings.

Everyone knows our teenage years can be turbulent—yet they also shape us and equip us for adulthood. Likewise, the solar system’s youth, wild as it was, prepared the way for advanced life, particularly humanity, to exist on Earth. This *TNRTB*series is devoted to exploring the different stages of the solar system’s youth.

* [Part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-1): The solar system’s exquisitely fine-tuned birthing experience
* [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2): The 50 million years following the birth, particularly (1) the configuration of the solar system’s gas giant planets; and (2) the collision event that both formed the Moon and helped prepare Earth for the future support of human beings.
* [Part 3](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-3): The 1:2 orbital resonance event between Jupiter and Saturn
* [Part 4](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-4): The subsequent late heavy bombardment (LHB), 700 million years ago, transformed the architecture of the entire solar system and reconfigured the physical features of Earth’s interior, surface, and atmosphere.

Here, in part 5, I will describe the recently discovered “jumping Jupiter” phenomenon that took place during the gas giants’ migration. I will also demonstrate how young-earth creationism fails to account for several important solar system features.

**Jumping Jupiter**

All solar system models demonstrate that Jupiter, Saturn, Uranus, and Neptune began migrating immediately after the dissipation of the Sun’s primordial nebular disk, more than 650 million years before the LHB and many millions of years before the Moon-forming event. [Angular momentum](http://en.wikipedia.org/wiki/Angular_momentum) transfers between the gas giants and the scattered planetesimals remaining after the nebular disk’s dissipation caused the migrations.

A planetary science research team in Nice, France recently uncovered flaws in the standard gas giant migration models. These models *disallow* the formation of the solar system’s terrestrial planets (Mercury, Venus, Earth, and Mars) as they are presently configured.1 In particular, these standard models predict that [Mars should be many times more massive](http://adsabs.harvard.edu/abs/2011A%26A...526A.126W) than it actually is. On top of this, these models cannot predict the present-day distributions and characteristics of the solar system’s asteroid belts.

Fortunately, the Nice team found a resolution to both problems through a phenomenon they labeled as “jumping Jupiter.” In their scenario, either Uranus or Neptune experienced a close encounter with Saturn and was, consequently, scattered inward. That inward migration resulted in Uranus (or Neptune) experiencing a close encounter with Jupiter wherein Uranus (or Neptune) was strongly scattered *outward*. And this second close encounter led to a [rapid increase in the separation between Jupiter’s and Saturn’s orbits](http://adsabs.harvard.edu/abs/2010AJ....140.1391M).2

The Nice team demonstrated that adding the jumping Jupiter scenario to the design details discussed in parts 1–3 explains explains not only the current planet configurations but also those of the solar system’s asteroid belts.3 In a very elegant manner, the jumping Jupiter phenomenon generated resonances that swept through most of the Main Belt but depleted only the inner part of the belt.4 Together with the Jupiter-Saturn resonance event, the jumping Jupiter scenario explains why the Main Belt does not extend all the way to the orbit of Mars ([the missing E-Belt](http://www.lpi.usra.edu/meetings/lpsc2010/pdf/1269.pdf)).5

**Comets and Young-Earth Creationism**

Young-earth creationists like to point out that the solar system’s reserve of short-period comets would be exhausted in much less than a billion years. To support their rebuttal, however, they must deny the existence of all or nearly all Kuiper Belt objects (KBOs). Yet astronomers have already established the existence of more than a thousand KBOs, thus making the young-earth creationists’ denial difficult to sustain, to say the least. Additionally, astronomers have determined that at least 70,000 smaller KBOs must accompany the 1,000+ large object already detected. However, a young-earth creation scientist I recently debated claimed that astronomers are wrong in this determination.

However, limiting the Kuiper Belt to little more than a thousand objects presents several major problems.

1. Those few objects are woefully inadequate to explain how Jupiter, Saturn, Uranus, and Neptune could have ever achieved their present orbital characteristics.
2. Such a limitation also is incapable of explaining the present-day configuration of the Main Belt.
3. It is becoming increasingly evident that large debris disks are ubiquitous around young solar-type stars seen throughout the nearby regions of the Milky Way Galaxy.6One astronomy research team has even directly imaged a Kuiper Belt orbiting a mature solar-type star.7

With every passing month (sometimes only a week or a few days), astronomers discover yet one more KBOs and yet one more large debris disk orbiting a young solar-type star. Likewise, with every passing month, the Nice model for the early history of the solar system is more securely established. Surely, it is time for young-earth creationists to abandon their claim that a solar system several billion years old cannot explain the abundance of short-period comets presently observed.

Next week, I’ll close out this article series showing how the design details of the solar system’s youth establish that a supernatural, super-intelligent Creator was intimately involved in ensuring that the solar system and Earth in particular had the just-right history to prepare them to sustain human beings and human civilization.

|  |
| --- |
| [Part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-systems-turbulent-youth-part-1) | [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2) | [Part 3](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-3) | [Part 4](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-4) | Part 5 | [Part 6](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-6) |

The solar system’s youth was a busy one—full of fine-tuned activity. In the previous five parts of this series I’ve described several of the major milestones of the solar system’s early years.

* [Part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-1): The solar system’s exquisitely fine-tuned birthing experience
* [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2): The 50 million years following the birth, particularly (1) the configuration of the solar system’s gas giant planets; and (2) the collision event that formed the Moon and helped prepare Earth for the future support of human beings
* [Part 3](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-3): The 1:2 orbital resonance event between Jupiter and Saturn
* [Part 4](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-4): The subsequent late heavy bombardment (LHB), 700 million years ago, that transformed the architecture of the entire solar system and reconfigured the physical features of Earth’s interior, surface, and atmosphere
* [Part 5](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-5): The recently discovered “jumping Jupiter” phenomenon that took place during the gas giants’ migration

In the sixth and final article, I will discuss how these design details of the solar system’s youth establish that a supernatural, super-intelligent Creator was intimately involved in ensuring that the solar system and Earth in particular had the just-right history to prepare them to sustain human beings and human civilization.

**Rare Occurrences**

The planetary science research team (from Nice, France) that discovered the jumping Jupiter phenomenon determined that, while dynamically possible, the probability for Jupiter to “jump” in the manner that makes the solar system’s present configuration possible is, nonetheless, relatively remote.1 In a separate research report, one member of the Nice team and several other planetary physicists calculated the probability for the occurrence of late heavy bombardment (LHB) events in extrasolar planetary systems. They constructed models of what the solar system’s asteroid-comet belts would have looked like prior to the LHB. Comparing their results with observed debris disks of different ages surrounding sun-like stars, the researchers demonstrated that LHB events around stars similar to the Sun must be rare.2

Furthermore, two Greek astronomers developed planetary system models wherein they demonstrated that orbital resonances among gas giant planets commonly generate inclination excitation in the orbits of the system’s planets.3 That is, the low-angle tilts of the planets’ orbits relative to the solar plane would be a rare outcome, a result confirmed by extrasolar planet statistics.4

**Marvelously Fine-Tuned**

Everything about the solar system and Earth’s history shows the hallmarks of exquisite fine-tuning. Let’s review what needed to take place in the solar system to make it friendly to advanced life.

*1. The Adjustment of Earth’s Volatiles and Heavy Elements*  
Ridding Earth of most of its volatiles and strongly enriching it with heavy elements required (1) the placement and timing of four-different supernova eruption events; (2) the placement and timing of one or more asymptotic giant branch stars; and (3) the placement and timing of a white dwarf binary relative to the Sun and its system of emerging planets in their birthing star cluster.

*2. Solar System’s Ejection from Birthing Cluster*  
The fine-tuned placement and timing of massive stars relative to the Sun and its emerging planets to strongly eject the Sun and planets at the just-right time into the just-right location within the Milky Way Galaxy (MWG), namely just inside the corotation distance—the MWG’s safest location for advanced life. This ejection event also reconfigured the solar system’s planetesimal disk to generate just-right migration velocities for all four gas giant planets. This paved the way for the jumping Jupiter phenomenon, the Moon-forming collision event, and the 1:2 Jupiter-Saturn orbital resonance event.5

*3. The Jumping Jupiter Phenomenon*  
It took a highly fine-tuned and rare jumping Jupiter phenomenon to guarantee that the solar system’s terrestrial planets and Main Belt asteroids would end up with the precise masses and orbital configurations that enduring advanced life on Earth requires. It took additional fine-tuning of the jumping Jupiter phenomenon to send Jupiter on the just-right outward migration velocity to set up a just-right 1:2 orbital resonance event with Saturn at the just-right time.

*4. The Moon-Forming Collision*  
A collider of the just-right mass struck Earth at the just-right angle, velocity, and time in the solar system’s history into a location on Earth with the just-right depth of liquid water for Earth’s core to be further enriched with iron, cobalt, nickel, uranium, and thorium and for its configuration to be restructured. The collision event generated a moon of the just-right mass and rate of recession away from Earth so as stabilize the planet’s rotation axis tilt. The Moon also lengthened Earth’s rotation period at the just-right rate and generated just-right tides so advanced life would eventually be possible on Earth. Additionally, the collision event adjusted the tilt of Earth’s rotation axis to an angle of 23.5 degrees relative to the solar system plane—the ideal tilt for the support of advanced life on virtually all Earth’s surface.

*5. The Jupiter-Saturn Resonance Event*  
A 1:2 orbital resonance event between Jupiter and Saturn occurred at the just-right time in solar system history and the just-right distance from the Sun to produce the extremely improbable orbital characteristics of the gas giants’ final configurations. These fine-tuned configurations are needed to guarantee (1)  that Earth is adequately protected from taking too many hits from large asteroids and comets; and (2) that the gas giants’ gravitational fields and the orbital resonances among them do not disturb the features of Earth’s orbit essential to advanced life.6

It took additional fine-tuning in the Jupiter-Saturn orbital resonance event to reduce, move, and restructure both the Kuiper Belt and the Main Belt so that Earth would not be bombarded by too many asteroids and comets during the epochs of advanced life. The fine-tuning also ensured that Earth received a just-right dose from the LHB to chemically and physically restructure the planet’s inner and outer cores, mantle, and crust. This restructuring established plate tectonics and an internal dynamo at just-right power levels and with the stability to endure at those levels for 4 billion years. Without just-right plate tectonics, Earth would have never developed the surface continents and oceans that advanced life requires. Neither would it have been endowed with the strong, stable magnetic field needed to preserve the atmosphere and to protect life from deadly solar and cosmic radiation.

I argue that the research results achieved by the Nice team and other planetary science research groups reveal the extreme care and meticulous design the Creator invested into the early development of the solar system for the specific benefit of Earth’s advanced life and human beings in particular.

|  |
| --- |
| [Part 1](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-systems-turbulent-youth-part-1) | [Part 2](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-2) | [Part 3](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-3) | [Part 4](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-4) | [Part 5](http://www.reasons.org/articles/the-remarkable-design-of-the-solar-system%E2%80%99s-turbulent-youth-part-5) | Part 6 |